Retrieving Dust Optical Depth and Mineral Composition from Infrared Spectra

Contributors
David D. Turner, *University of Wisconsin-Madison*

Research Highlight

The radiative impact of aerosols is very uncertain, which translates into significant uncertainty in the treatment of aerosols in global climate models. Mineral dust lofted from the Earth's surface into the atmosphere is an important component of the atmospheric aerosol. Mineral dust in the atmosphere is often episodic and the amount and composition of the atmospheric dust depends strongly on the source region, how strong the lofting event is, and the atmospheric conditions that keeps the dust aloft. New techniques are needed to quantify the total amount of mineral dust in the atmosphere and to determine its composition so that aerosol transport models can be validated and improved.

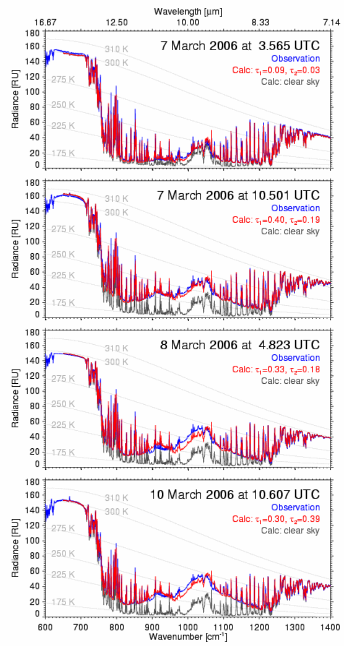
The ARM Program deployed its Mobile Facility (AMF) to the Niamey, Niger, in 2006. One of the instruments deployed was the atmospheric emitted radiance interferometer (AERI), which measures the downwelling infrared radiance at high spectral resolution. We have developed a technique that is able to retrieve the total infrared optical depth of the mineral dust in clear skies. Furthermore, we were able to infer the mineral composition of the dust by taking advantage of the differences in the infrared absorption properties of three main types of mineral dust that are common in the Sahel region of Africa: kaolinite, gypsum, and quartz.

This method has been applied to the cloud-free AERI observations for the entire AMF deployment. The results then were analyzed in four different groupings based upon general weather patterns: pre-monsoon, early in the monsoon period, late in the monsoon period, and post-monsoon. First, large dust loading episodes occurred frequently in the pre-monsoon, early monsoon, and post-monsoon periods. The distribution of dust optical depths and composition was fairly similar in the pre- and post-monsoon periods. Kaolinite was shown to be an important component of the dust during all four seasons, while quartz was seldom inferred from the AERI observations. The composition of the mineral dust showed a sensitivity to the back-trajectory direction, with back-trajectories from the east having a higher fraction of gypsum than back-trajectories in other directions.

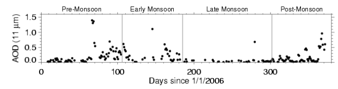
The retrieval technique used here is a novel way to investigate the properties of the atmospheric dust using ground-based high-spectral-resolution infrared radiance observations. The data provide insight into the composition and amount of the dust over the Sahel. These data will be used to look at the radiative impact of the dust, especially on the atmospheric radiative heating rate profiles, and to evaluate aerosol models in this geographical region.

Reference(s)

Turner DD. 2008. "Ground-based retrievals of optical depth, effective radius, and composition of airborne mineral dust above the Sahel." Journal of Geophysical Research – Atmospheres, 113, D00E03, doi:10.1029/2008JD010054.



Example AERI observed (blue) and computed spectra (red) where the dust properties were retrieved from a subset of AERI microwindows. These results show the quality of the dust retrievals across the entire spectrum. The gray spectra are the dust-free computations, and illustrate the dust radiative forcing at the surface. The dust was inferred to be composed of two minerals, kaolinite (tau1) and gypsum (tau2), and the relative concentration of the two minerals evolved over this 3-day period.



The daily averaged 11 micron dust optical depths that were retrieved from the AERI observations during the AMF deployment to Niamey. The dust optical depths were lowest during the late monsoon period, with significant dust loading episodes during the other three periods.

Working Group(s)
Radiative Processes